Coastal Engineering Technical Note

MONITORING COMPLETED COASTAL PROJECTS - LESSONS LEARNED I

PURPOSE: To provide a summary of lessons learned from the Monitoring Completed Coastal Projects (MCCP) Program.

GENERAL: This CETN is the first in a series summarizing lessons learned from the MCCP Program. It covers seven projects for which reports have been completed: Manasquan Inlet, NJ (Gebert and Hemsley, 1991); Umpqua River, OR (Herndon, et al., 1992); East Pass, FL (Morang, 1992); Cattaraugus Creek, NY (Hemsley, et al., 1991); Spud Point Marina, CA (Lott, 1991); Puget Sound Floating Breakwaters, WA (Nelson and Hemsley, 1988); and Carolina Beach, NC (Jarrett and Hemsley, 1988). These projects covered three general areas: jettied inlets, including Atlantic, Pacific, Gulf, and Great Lakes inlets; breakwaters, including floating and baffled breakwaters; and beachfills.

INLETS: The inlets monitored included two (Manasquan and East Pass) that are tidal inlets through barrier islands, one (Umpqua) which is a tidal inlet on a river, and one (Cattaraugus Creek) that is on a creek influenced by longer period lake level changes. Lessons learned are summarized as follows:

1. Jetties at tidal entrances should be generally parallel to each other and to the navigation channel. Converging (arrowhead) jetties often fail to provide stable entrances and safe navigation.

2. A jettied entrance should be oriented, whenever possible, parallel to the natural channel direction. A man-made change in orientation of channel direction may cause migration of the channel thalweg, rapid shoaling, and erosion of shoreline features inside the inlet. In designing the alignment of the navigation channel and jetties, remember that the jetties will modify wave and current forces which caused the existing channel location. The orientation of the channel may need to be shifted slightly to reduce shoaling. This should be verified to the extent practical in a model study.

3. Where possible, navigation channels within an inlet should be realigned to follow the natural thalweg in order to reduce dredging requirements.

4. Construction of jetties causes establishment of a new equilibrium for the inlet system, which includes its shoals and adjacent shorelines. Bathymetric measurements over the shoals and surveys along adjacent shorelines are required over an extended time period to determine the new equilibrium.

5. The controlling inlet cross-section for the relationship with tidal prism will be a cross-section extending some distance along the inlet rather than the cross-section at an isolated feature.

6. Studies of boat traffic using inlets need to be periodically updated to determine if project depths are still justified. A decrease in traffic by deeper draft vessels may allow significant cost savings by decreasing the project depth.

7. Performance of a jettied inlet system is relatively insensitive to some variation in flow rate through the inlet. This is important from the standpoint of modeling jettied tidal inlets, as it may not be necessary to model all variations in the flow.

8. It is desirable to have prototype and model measurements at the same flow condition. However, theoretical adjustments based on idealized flow conditions give reasonable results for comparison when model measurements do not exactly duplicate a particular prototype flow condition.

9. Fixed-bed, distorted-scale models must be used with caution as they may not accurately characterize shoaling patterns.

10. Further work on tidal inlet stability analysis should be undertaken to confirm the applicability of "regime theory" to tidal entrances.

11. Construction of jetties (Cattaraugus Creek) did not seem to affect the flow of ice and formation of ice jams during Spring breakup.

12. Construction of jetties (Cattaraugus Creek) caused course channel material to be carried further lakeward during high river flows.

13. Projects should be maintained as originally designed unless overwhelming evidence of failure, or major events such as hurricanes, clearly require changes. Frequent changes in operation and maintenance of a project will make it nearly impossible to determine how well a project is actually performing.

14. Regional dynamic and hydraulic processes are the prime driving forces which influence an inlet's flow and orientation. Future projects must investigate meteorological forcing, regional and subsurface geology, coastal oceanography, and back-bay circulation.

15. Sediment traps in tidal inlets should be located in areas removed from concentrated tidal flows.

<u>JETTY STRUCTURES:</u> Jetty structures were investigated at Manasquan, East Pass, and Cattaraugus Creek. Lessons learned are:

16. Filter fabric can be used effectively to sand tighten jetties to prevent sand from passing through into the navigation channel. However, the endurance of the filter fabric was not determined over an extended period of time.

17. Sand tightening of jetties can effectively eliminate the need for maintenance dredging if the jettied inlet is otherwise properly designed in relation to the hydrodynamics and sediment transport of the inlet.

18. Sand tightening of jetties did not affect shoreline erosion on the downdrift side of the inlet during the monitoring period. Longer term monitoring would be required to determine any long-term effect.

19. Natural processes will form scour holes, particularly at the tips of jetties or spur jetties. Toe protection, such as stone aprons, should be used to protect the structures in areas potentially subject to scour.

20. Waves may penetrate across weir sections placed in jetties, causing undesirable effects in the inlet. An analysis of potential wave action should be included in the design analysis of any proposed weir.

21. A design storm, or near design storm, will cause some movement of armor units on inlet jetties. Some movement, and even some breakage of units, may not affect the stability of the jetties and may not require maintenance/repair.

22. Reinforcement of large armor units is effective in preventing breakage in the short term. Some units may crack, but will not break. Determination of long-term effects will require continued monitoring.

23. Some fragmenting of armor stones occurred during the winter on the Cattaraugus Creek jetties. This was probably caused by expansion of freezing water in cracks in the stones.

<u>BEACHFILLS AND SAND TRANSPORT:</u> A beachfill was monitored at Carolina Beach. In addition, sand transport was monitored near Manasquan and East Pass, and data were collected at Cattaraugus Creek and Umpqua. Lessons learned are:

24. A beach fill without structures, e.g., terminal groins or detached breakwaters, will 'lose' sand from the project area because of spreading in both the updrift and downdrift directions. The percentage of sand which spreads into non-project areas vs. time is inversely proportional to the length of the project fill.

25. Accretion of sand north (updrift) of the Carolina Beach fill exceeded the quantity of sand spreading from the project. This indicates a beach fill acts as a littoral barrier, causing accretion of sand on updrift, non-project beaches. Because of natural spreading, plus the barrier effect, initial beach fill placement may not need to extend to the updrift end of the project area. These effects need to be considered in designing beach fill placement.

26. Overfill should be placed toward the updrift end of a project, but not directly at the end of the project where it would accelerate spreading (unless it is intended to feed sand to updrift beaches).

27. Beach fills can act as effective feeder beaches, providing substantial benefits to shorelines outside project areas.

28. Placing sand in a "construction profile," and using natural wave action to achieve the final desired profile, is a cost effective way of placing beach fill.

29. Sorting of sand, and losses of finer grained material, occurs primarily during placement of a beach fill. Therefore, temporary sand fill retention structures must not be used to hold the pumped material on the beach as this will trap the fines in the cross section. This will result in a lower quality beach fill project. Once the temporary dikes (cells) are removed, the fines will be lost from the cross section, probably after payment quantity surveys have been made.

30. Cross-shore sand movement is cyclic, moving offshore (erosion) during a storm, and moving onshore (recovery) during the low wave period following a storm. Recovery starts immediately after a storm. Recovery is slower following a storm of long duration (e.g., a northeaster) when compared to a storm of shorter duration (e.g., a hurricane) because the longer period storm may move material farther offshore.

31. A jetty may partially shelter a beach on its leeward side, reducing cross-shore sand movement during a storm.

32. Where there is no strong predominant longshore transport, jetties have no significant adverse impacts on adjacent shorelines.

33. Evidence suggests that sand will naturally bypass an inlet via the ebb-tidal shoal if the navigation channel is relatively shallow (in the case of East Pass, a 12-foot project depth).

34. Shifts may occur in predominant wave direction and associated net littoral drift direction over long periods of time. Records should be studied for extended time periods if there is any evidence of possible reversals. Single year, or even multi-year, analysis is not sufficient. Extreme care must be used to ensure correct wave information is used for calculating net longshore sand transport. Errors in estimates may be several times the actual net transport

rate, and even predict the wrong direction, if inaccurate wave information is used. Wave information must span the entire year, include all components of wave direction, be free from effects of nearby structures, and be from a gage close to the site being investigated.

<u>BREAKWATERS:</u> Several floating breakwaters in Puget Sound, WA were monitored. In addition, a baffled breakwater at Spud Point Marina, Bodega Harbor, CA was monitored. Lessons learned are:

35. Small transmitted wave heights, even on the order of a few inches, are sufficient to cause rolling motion in moored boats, particularly when boats are moored in an orientation parallel to the breakwater, i.e., broadside to waves transmitted through the breakwater. Some additional investigation is needed relating transmitted waves to small boat motion, particularly in regard to the orientation of moored boats and the breakwater relative to expected wave direction.

36. Vessel generated waves may be the controlling design wave in small bodies of water. Predictions for vessel generated waves are needed in addition to predictions for wind generated waves.

37. In designing openings in breakwaters to allow water circulation, consider natural circulation patterns. Openings (culverts or gaps) that are aligned parallel to the normal flow will be more effective. Thus, the openings for circulation will be placed in breakwater segments that are angled across the flow patterns.

38. Cast concrete breakwater caps may develop hairline "shrinkage" cracks. While small cracks may not affect structural integrity in warmer climates, expansion of freezing water can cause spalling of concrete in colder climates.

39. Misplacement of anchors and/or incorrect tensioning of anchor cables for floating breakwaters can cause anchor cables to rub together. This can result in eventual failure of anchor cables. Care should be taken in anchor location and cable tensioning. Anchor cables should be inspected after installation of a floating breakwater to ensure cables are not in contact with each other.

40. Shore connected breakwaters of a concrete pontoon type will commonly be used after installation for a variety of secondary purposes including boat moorage and fishing platforms. These secondary purposes should be considered in design of the pontoons. Design considerations include:

a. Mooring system design must consider added loads resulting from wind loads on boats moored to the pontoons.

b. Features such as mooring bollards, safety rails, life preservers, ladders, or other similar features should be included.

c. Structural pieces should not protrude beyond the sides of the pontoons, and should be securely fastened to prevent rotation into protruding positions.

d. Water and electrical lines should be included internal to the pontoons. Experience on Puget Sound showed water lines internal to pontoons were protected from freezing.

e. Design and positioning of electrical service outlets should consider the possibility of damage by docking and departing boats. Also, electrical junction boxes should be equipped with drains, and all hardware should be designed for marine use to prevent corrosion.

f. Concrete floats should have rounded corners to lessen damage from impacts with vessels.

41. A corrosion protection system such as aluminum anodes should be used on anchor systems to prevent corrosion and increase service life. A schedule should be included for periodic inspection and replacement of anodes when

necessary. Comparisons between protected and unprotected systems showed protective anodes are effective.

42. For scrap-tire breakwaters, foam blocks are needed in scrap tires when the tires may become submerged due to wave and current action. Submergence may cause air compression and loss of buoyancy, possibly causing breakwater modules to sink.

43. Urethane foam used for floatation in scrap tire breakwaters has questionable long-term durability. A solution used elsewhere was to seal foam blocks in plastic.

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